The Structure of Variation and the Developmental Basis for Evolutionary Change

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Abstract:
In recent years, our understanding of the developmental pathways that drive development has increased enormously. The proliferation of accounts focused on the roles of specific genes in development has now created a vast field of bewildering complexity. Yet, this growth in information has not produced a fundamental change in our understanding of the developmental basis for evolutionarily significant phenotypic variation. We still do not know how selection and development interact to produce variation and evolutionary changes in features such as limb length or the shape of the skull. We argue that a new theoretical approach is needed to integrate gene-centered accounts of developmental mechanisms to a phenotypically relevant understanding of developmental systems. This approach focuses on higher levels of the developmental hierarchy such as pathways and processes as ontologically equivalent sources of developmental explanation for phenotypic variation. Development funnels the vast amount of variation at the molecular level through definable numbers of developmental pathways which influence smaller numbers of developmental processes which, in turn, often have tractable relationships with fairly restricted sets of phenotypic outcomes. We argue that understanding this relationship between developmental processes and phenotypic outcomes is a key step in unraveling the developmental-genetic basis for phenotypic variation. The results of such studies provide a larger framework within which to contextualize the massive amounts of data generated by ongoing studies on gene-specific effects on the phenotype and the dissection of the genetic networks that control or regulate normal and abnormal development.